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ABSTRACT

Identified and formalized were two distinct learning strategies employed by 120 children between 7 and 15 years of age who played a simple, computerized board game. "Hexapawn" is played by moving pawns in turn on a 3 x 3 grid, in order to be the first to reach the opponent's starting line or block the opponent. The computer always moved first. For subjects, moving second, there existed an optimal strategy which guaranteed success regardless of the computer's strategy. Alternating central and lateral attacks, the computer won only when the player made errors. Subjects played until they had won seven consecutive games, or had played 25 games. Analysis of modifications of subjects' performances across a series of games suggested two different learning models: (1) a deductive model used predominantly by 11- through 15-year-olds; and (2) a rule-based model used predominantly by the youngest subjects. In the deductive model, the acquisition of a good strategy is based on a logical analysis of successes and failures, implying an increasingly sophisticated goal structure, and progressively deeper anticipation processes. In the rule-based model, the evolution of game strategies proceeds from a hypothesis testing process applied to the possible moves in the different board positions. This model expresses a context-bound strategy which consists of locating the critical situations. A developmental trend was observed from the rule-based model to the deductive model. (RH)

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BE SUCCESSFUL WITHOUT UNDERSTANDING ?

The acquisition of game strategies by 7 to 15 year-old children

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ABSTRACT

In this research, which concerns 7 to 15 year-old children, we identified and formalized two distinct learning strategies involved in a simple game, HEXAPAWN, which is a two-partners game using a 3 x 3 board.

120 children participated in the experiment.

The modifications of the subjects' performances across a series of games allow us to design two different learning models :

- a *deductive model*, only convenient for the oldest subjects (11-15 year old)
- a *rule-based model*, which fits the youngest subjects' data.

In the "deductive model", the acquisition of a good strategy is based on a logical analysis of successes and failures, implying an increasing sophisticated goal structure, and deeper and deeper anticipation processes.

On the contrary, in the "rule-based model", the evolution of game strategies proceeds from a hypothesis testing process applied to the possible moves in the different board positions. This model expresses a context-bounded strategy which consists of locating the critical situations.

The question now in progress is to define the subjects' shifts from the rule-based learning strategy to the deductive one.

THE GAME

HEXAPAWN is a two-partners game using a 3 x 3 board.

At the beginning, each player has 3 pawns

O	O	O
S	S	S

To move a pawn (like in chess), there are two possibilities : move forward to an empty square, or move crosswise to take an opponent's pawn.

The winner is the one who

- either first reaches the opponent's start line,
- or first blocks the opponent.

For the second player there exists an optimal strategy which guarantees the success whatever the opponent's strategy is.

AN EXAMPLE OF GAME

O	O	O
S	S	S

Starting state

O	↓	O
	O	
S	S	S

Central Attack

O starts moving
forward

O		O
	S	
S	S	↘

S takes an O's pawn

O		↙
	O	
S	S	

O takes an S's pawn

O		
S	O	
↑	S	

S wins blocking O

METHOD

Subjects play against a computer. The computer always plays first (alternating central and lateral attacks). Therefore, the computer only wins in case of subject's errors.

Subjects play a series of games until he/she succeeds 7 consecutive games, or up to 25 games.

SUBJECTS

120 subjects participated in the experiment, 15 by age group from the 2nd to the 9th grade.

OVERALL RESULTS

FIRST RESULT (not very surprising !)

The older the subjects are,
the better they are.

For example,

80% of the youngest subjects do not reach the criteria of 7 consecutive games,
whereas 67% of the oldest subjects start to win systematically before the 10th game.

SECOND RESULT (more interesting !)

Analyzing the series of games of each subject, it was observed that different kinds of errors do not disappear in the same order among the youngest and the oldest subjects.

Therefore two distinct learning processes were hypothesized.

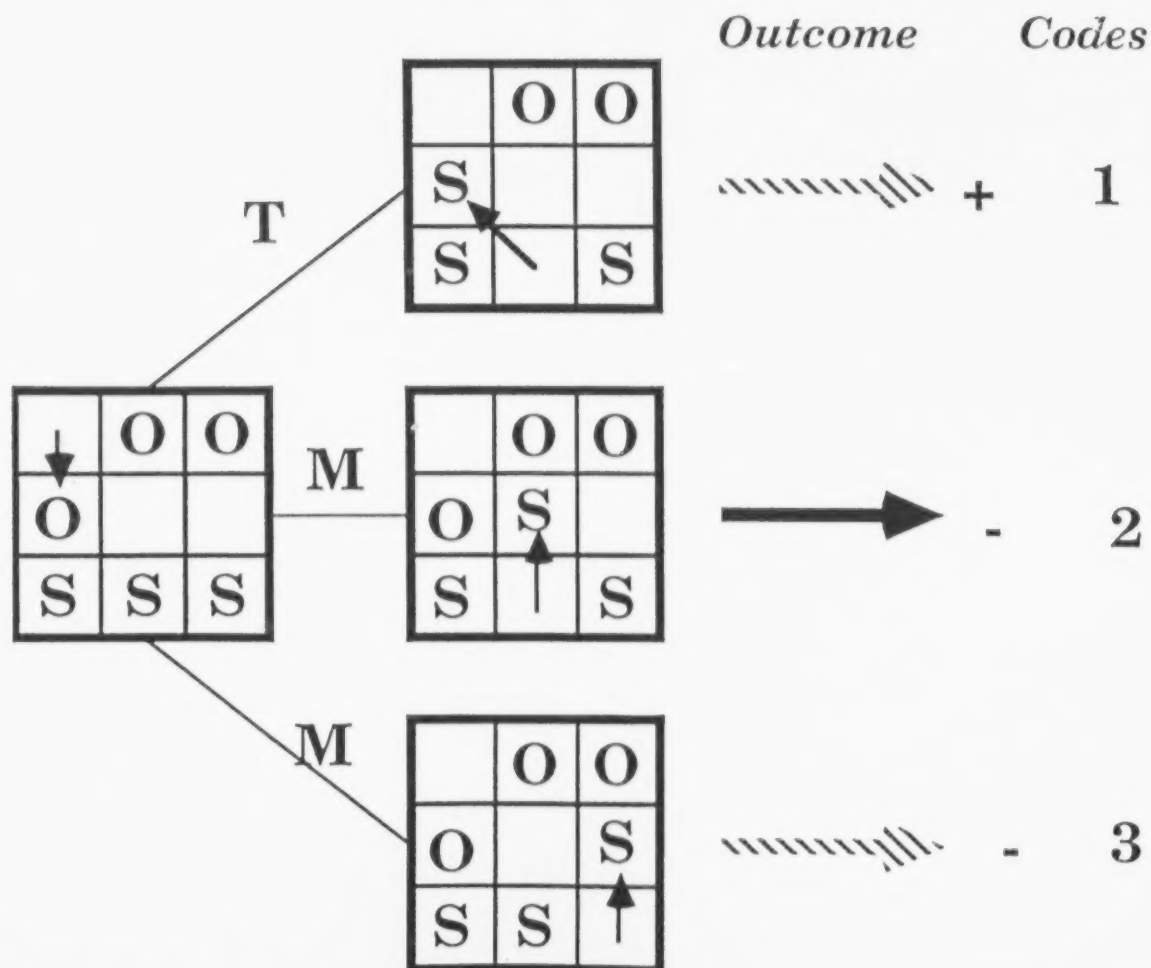
THE POSSIBLE GAMES

Taking into account the critical situations with respect to the outcome of the games, 8 main categories of games have been identified.

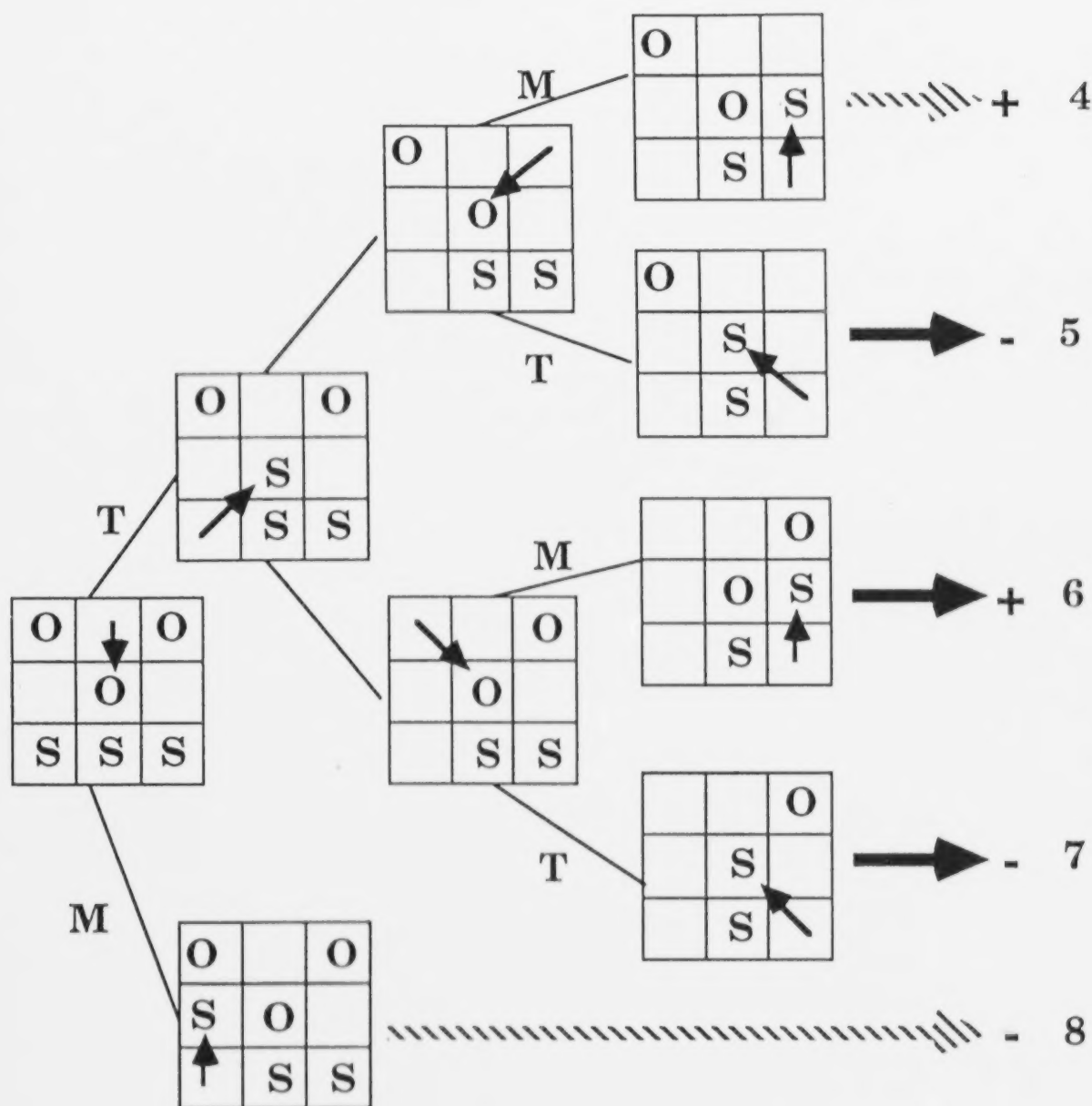
Abbreviations

T S takes an O's pawn	+ S wins the game
M S moves forward	- S loses the game

Lateral O's Attack



Central O's Attack



So, two kinds of errors are relative to a lateral O's attack : 2 & 3

And three kinds of errors are relative to a central O's attack : 5 & 7 & 8

THE DEDUCTIVE MODEL

Among the *oldest subjects*, it was observed that the different kinds of *errors disappear* in that order across the series of games :

First

Lastly

error 3 → error 8 → error 7 → errors 2 & 5

In order to interpretate these data, it was assumed that the subjects' actions result from the goals they pursue at a given time. In this framework, subjects eliminate errors by considering simultaneously *more and more goals*.

Level 1 G1

G1 Reach the computer's start line as soon as possible

Level 2 G1&G2

G2 Prevent that the computer reaches the S's line

Level 3 G1&G2&G3

G3 Block the computer if possible

Level 4 G1&G2&G3&G4

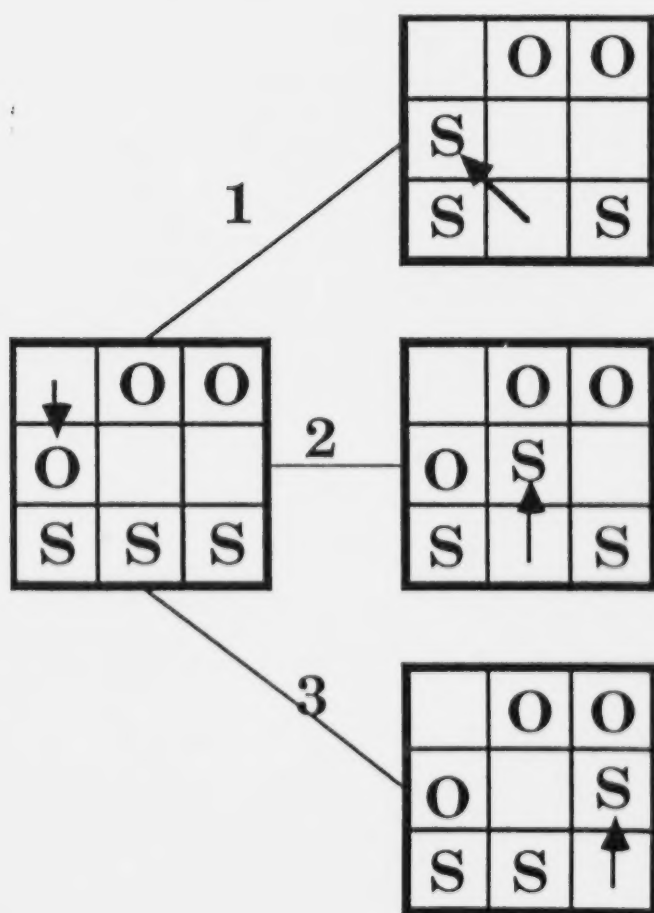
G4 Prevent to be blocked

We so defined 4 main levels of learning. Each level is characterized by the goal structure under consideration. Each goal structure is predictive of certain kinds of moves. The most sophisticated goal structure only predicts correct moves.

An example :

Level 2 – Goal Structure – G1 & G2

Lateral O's attack



1 and 2 are possible candidate moves because they prevent that the computer reaches the S's line

3 is a prohibited move because O could reach the S's line

THE RULE-BASED MODEL

Among the *youngest subjects*, it was observed that the different kinds of *errors disappear* across the series of games in that order :

First

Lastly

errors 2 & 3 → error 8 → errors 5 & 7

It therefore appears that the youngest subjects

- first learn to win in case of a lateral O's attack
- next learn to take an O's pawn at the first move in case of a central O's attack (this move alone does not guarantee success)
- lastly (but this concerns only a minority of subjects), systematically succeed in case of a central O's attack.

It was assumed that subjects would proceed from a hypothesis testing process applied to the possible moves in the different board positions. They would try to learn the action rules that lead to success.

The correct first move to play in case of a *lateral O's attack* ("*Take*") is *easy* to discover because it is sufficient to guarantee the success (the other moves lead to quick and systematic failures).

It is not the same in case of a *central O's attack* because the *correct action rules have to deal both with the first and the second move*. This double rule is the next one :

- 1 take an O's pawn at the first move
- 2 then move forward at the second move.

Without understanding of the rationale of such rules, it is of course difficult for the subjects to identify them. This explains that many young subjects only identify the part 1 of this double rule.

CONCLUSIONS

The most part of the subjects' protocols may be interpreted in the framework of one of the two models.

Taking into account the subjects' grades, the distribution is the next one :

subjects' grades

<i>Learning model</i>	<i>2nd→5th</i>	<i>6th→9th</i>
Deductive	10%	77%
Rule-based	68%	20%
?	22%	3%

(N=60)

(N=60)

A developmental trend is observed from the rule-based model to the deductive model.

The oldest subjects (11 to 15) may be categorized in one of the two models. The deductive learning model, which implies anticipation processes, is predominant.

Among the youngest subjects (7 to 11), 78% of them may be categorized in one of the two models. The rule-based model is then predominant.

22% of the youngest subjects cannot be categorized. The most part of these subjects are probably in a *transition* step. They would oscillate between the two learning models.

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